Comparison of wind erosion measurements in Germany with simulated soil losses by WEPS

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Introduction

Wind erosion is a serious problem in the northeastern parts of Germany. These regions are characterized by sandy soils, low precipitation and the transition to continental dry climatic conditions. The highest climatic erosivity in March and April coincide with the lowest resistance of the soils against wind erosion, caused by seedbed preparations and drilling. The problematic situation is increased by bare or only sparse covered soil surfaces as well by shelterbelts without leaves. Therefore wind erosion occurs especially in spring on fields of sugar beets, corn and other summer crops (Frielinghaus & Schmidt 1993).

Measurements of wind erosion have been carried out since 1991 beginning with a German project to develop a wind erosion model (Kuntze et al. 1989, Kruse 1994). In the first 3 years as much erosion data as possible should be collected in combination with all relevant meteorological parameters. For that aim an erosion plot of 2.25 ha was installed and equipped with sediment traps and a meteorological station to measure the wind erosion processes in a high spatial and temporal resolution (Funk 1995). These data are the basis for the first comparison between measured and simulated soil losses by wind erosion in Germany with the Wind Erosion Prediction System (Hagen et al. 1995).

Methods

Soil transport was measured with two sampler designs. Four automatic SUSTRA (SUspension Sediment TRAp, Fig. 1) were placed in the centre of the field with inlet heights in 5, 15, 25 and 45 cm. Weight of trapped sediment, wind speed and direction were stored as 10-minutes average in a data logger. Additionally 16 MWAC (Modified Wilson and Cooke Catcher, Fig. 2) were used, which were arranged in a grid of 25 m to measure the spatial distribution of the horizontal fluxes.
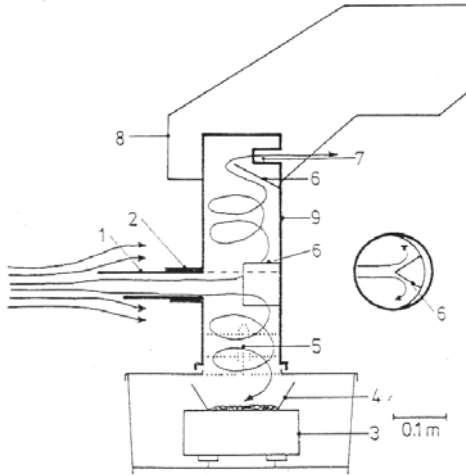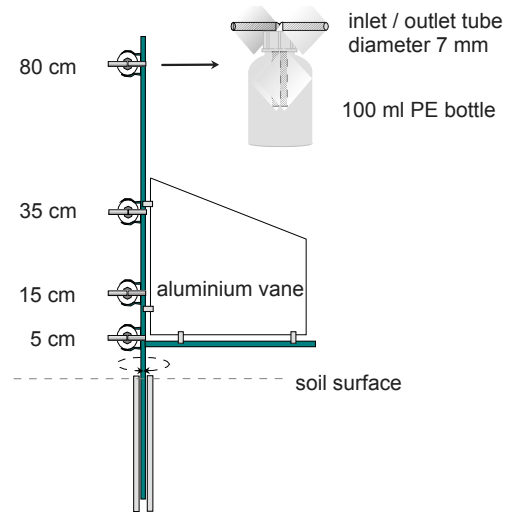
Figure 1: SUSTRA

Figure 2: MWAC

Calculations for single events were made with the WEPS erosion submodel (Hagen 1997). Unfortunately not all needed input parameter of field surface conditions were measured and therefore some had to be estimated. The estimation is based on following assumptions:

1. for the first erosion event after a tillage operation the roughness parameters (random roughness and ridge height) were varied to set the model used threshold wind speed equal to the measured;
2. the first erosion event after a tillage operation always got the highest roughness data and a non-crusted surface;
3. following erosion events always got decreasing roughness values (or at least the same), increasing parts of crust fraction and decreasing parts of loose erodible material depending on rainfall and erosion between the single events.

The surface crust cover fraction was calculated in dependency on cumulated rainfall with an equation of Zobeck and Popham (1992, in Hagen et al. 1995).

This gradually change of the inputs was continued until the next tillage operation. These assumptions seem to be reasonable to describe several erosion events in succession. The accuracy of the simulation depends much more on the relations between the events than on a good fit to one single event. Ridge width and ridge spacing were kept constant to 100 mm and 150 mm respectively, because the influence of these parameters was not so important.

Results

All in all 21 erosion events were selected and compared with simulated soil losses by WEPS. The results show a very good agreement between the measured and simulated soil losses with $R^2 = 0.98$ for the SUSTRA and $R^2 = 0.93$ for the MWAC.

Table 1: Measured and simulated soil losses for selected erosion events

storm date	SUSTRA (kg/m)	BOSTRA (kg/m)	WEPS (kg/m)	Soil loss (kg/m²)	Random roughness	Ridge height (mm)	Crust fraction	Fraction of LEM	last tillage operation	cumulated prec. (mm)
14/04/92	33.8	44.7	27.9	0.37	4.0	20	0	1	08/04/92	4.8
21/04/92	936.4	714.9	860	10.46	3.0	0	0	1		7.4
04/05/92	7.3	8.8	6.8	0.15	3.0	0	0.42	0.4		25.3
12/05/92	7.5	23.9	29	0.37	4.0	10	0	1	05/05/92	11.6
15/05/92	1.85	7.3	8.7	0.11	3.0	0	0.42	1		27.3
18/05/92	54.6	43.3	50.5	0.59	3.0	0	0.42	1		27.5
27/05/92	31.5	52.6	42	0.53	3.0	0	0.42	1		27.5
05/06/92	101.2	190.2	151	1.8	3.0	0	0	1	03/06/92	0.1
10/06/92	27.9	52.5	45	0.5	3.0	0	0.37	1		5.6
29/07/92	274.1	254.5	225	2.4	2.0	0	0.42	1	11/06/92	27.3
08/04/93	7.77	6.5	7.8	0.11	4.0	25	0	1	29/03/93	20.3
20/04/93	50.3	126.2	101	1.29	4.0	10	0	1		4.5
23/04/93	22.6	18.2	24.4	0.3	3.0	5	0.37	1		4.5
26/04/93	39.9	29.6	57.3	0.64	3.0	5	0.4	0.6		4.5
30/04/93	36.4	45.6	30.9	0.4	2.5	5	0.4	0.6		4.5
10/05/93	46.6	48.6	44.6	0.64	2.0	0	0.4	0.2		5.3
12/05/93	25.5	22.4	32.5	0.35	2.0	0	0.4	0.2		5.3
02/06/93	15.5	22.9	28.4	0.33	3.0	15	0.4	1	26/05/93	18.6
16/06/93	11.7	25.8	43.6	0.68	3.0	10	0.6	1		60.8
08/07/93	289.1	449.1	292	3.53	4.0	0	0	1	22/06/93	0
27/07/93	31.3	37.6	56.2	0.78	3.0	0	0.43	0.2		28.4

Conclusions

The first comparison between measured and simulated soil losses by WEPS in Germany shows satisfying results. This includes the total soil loss for an event, the spatial variations on the field and the temporal changes in transport capacity. The estimation of all missing parameters was handled very carefully with respect to all available information, to reduce the uncertainty and to minimize subjectivity.

References

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